Learning Fine-Grained Bimanual Manipulation with Low-Cost Hardware

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Abstract

Fine manipulation tasks, such as threading cable ties or slotting a battery, are notoriously difficult for robots because they require precision, careful coordination of contact forces, and closed-loop visual feedback. Performing these tasks typically requires high-end robots, accurate sensors, or careful calibration, which can be expensive and difficult to set up. Can learning enable low-cost and imprecise hardware to perform these fine manipulation tasks? We present a low-cost system that performs end-to-end imitation learning directly from real demonstrations, collected with a custom teleoperation interface. Imitation learning, however, presents its own challenges, particularly in high-precision domains: errors in the policy can compound over time, and human demonstrations can be non-stationary. To address these challenges, we develop a simple yet novel algorithm, Action Chunking with Transformers (ACT), which learns a generative model over action sequences. ACT allows the robot to learn 6 difficult tasks in the real world, such as opening a translucent condiment cup and slotting a battery with 80-90% success, with only 10 minutes worth of demonstrations. Project website: https://tonyzhaozh.github.io/aloha/